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## Medical Research in the United States Navy

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## MEDICAL RESEARCH IN THE UNITED STATES NAVY

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It is hardly necessary for me to say that all medical problems, work on which is being done at the great research laboratories of the world, have a direct bearing on naval medical problems and a real interest for the navy. The great foundations and research funds make it possible for these problems to be solved by private persons and, when so solved, the navy will be among the first to make use of the new knowledge acquired and to apply it in a practical way.

The medical department of the navy does not attempt to do research work along these lines. There are so many others better qualified and equipped for this type of work that the navy is content to leave it in their hands. There are problems, however, which the navy must solve for itself; problems which affect the navy primarily, but which also bear a close relationship to civil life. Chiefly, these problems are concerned with physical laws and their application to the varying conditions under which the personnel of the navy must, of necessity, live and perform its work. In addition, there are problems of warfare, which must be solved in time of peace, if their solution is to be of any value. Also, the medical department of the navy is a purchaser of large quantities of supplies and equipment. In order that these may be obtained most economically and that we may be assured of their quality it is necessary that we maintain a large medical supply depot, thoroughly equipped for carrying on research leading to that most desirable thing—standardization of material.

In our island possessions we have an almost unequalled field for the study of tropical diseases and for research directed toward the development of preventive measures. Our work there, along public health lines, has been productive of much benefit to the native populations and to those Americans who have settled in the islands for business or other reasons.

It is my purpose to direct your attention to a few examples of the type of research work we are doing.

The navy is a large buyer of clinical thermometers, which, to be worth anything, must be accurate. The physical laboratory at the naval medical supply depot, Brooklyn, inspects all clinical thermometers purchased for the navy, and, because of the excellent method of testing devised there, as a result of

extensive research, is also entrusted with the inspection and testing of all purchased by the Vetreans' Bureau for use in its numerous hospitals and clinics.

#### CLINICAL THERMOMETERS TESTED

About nine months ago a question was raised as to the proper seasoning of clinical thermometers, this being one of the requirements laid down in the United States Government Master Specifications. These require that all thermometers shall be so seasoned or aged while in the blank stage that the average of readings of the thermometers selected for test shall not, at subsequent tests made within four months after the first test, vary more than 0.1 degree F. from the average of the readings of the first test. At the time this question was raised a reexamination of a number of thermometers which had been in storage about two years, and which had passed satisfactory tests on delivery, showed a considerable percentage to be defective and unfit for use. The depot conceived the scheme of "forcing" thermometers prior to testing for accuracy at the time of the original inspection. By "forcing" is meant applying additional heat of about 1 to 1.5 degrees after the mercury has reached the top of the capillary tube, thus subjecting the bulb, the constriction, and the capillary tube to sufficient internal pressure to expand unseasoned and soft glass instruments and thus develop any not made of Corning, Jena, or other high resistance glass, into retreaters or thermometers with errors outside the permissible limits. Since the adoption of this practice the physical laboratory has made a number of reexaminations of thermometers at periods of from four to five months after the original examination and no retreaters or thermometers with errors outside the permissible limits have been found. This would seem to indicate that this "shock" test has some value. Figure 1 is the apparatus we use in testing clinical thermometers. At the right is a tank with hot and cold water, which connects with the lower tank, the one at the left, and in that left tank is a master thermometer from the Bureau of Standards. Large numbers of thermometers to be tested are placed in this tank for the forcing process.

#### TESTS FOR ROENTGEN-RAY APPARATUS

Complaints, from time to time, have been received from medical department activities in tropical and subtropical countries that roentgen-ray apparatus does not function well during those seasons when relative humidity is high. In addition, the insulating material on some machines deteriorates rapidly. It seemed reasonable to suppose that the high moisture content of the atmosphere played an important part in producing the loss of radiation output and in the rapid breakdown of

insulation. The problem was presented to the roentgen-ray laboratory at the supply depot for solution.

To determine the cause of these phenomena a special humidifying chamber was constructed, in which temperature and atmospheric moisture may be controlled. A complete, modern roentgen-ray outfit, with a Coolidge air-cooled therapy tube, was set up for test purposes. A Wolf ionometer is issued for measuring the radiation output. Normal atmospheric condi-

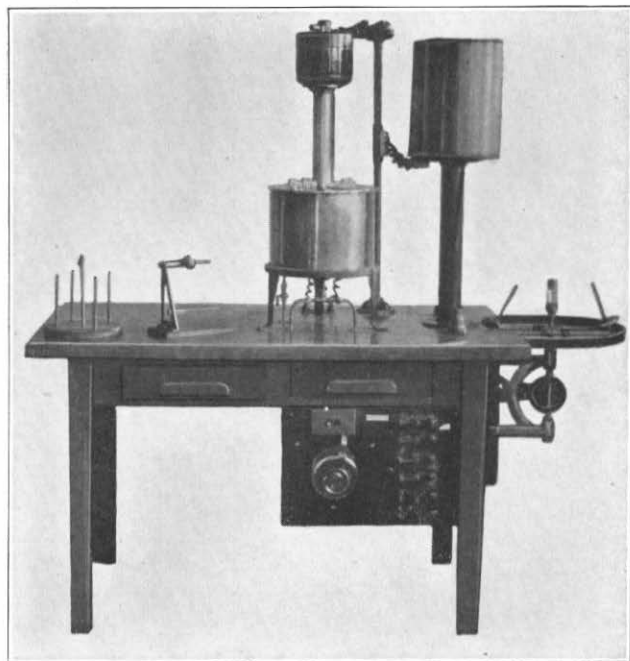


Fig. 1.—Clinical thermometer testing machine, United States Naval Medical Supply Depot, Brooklyn.

tions, for test purposes, are fixed at 70 to 74 F. and 40 to 42 per cent relative humidity. Abnormal conditions, approximating those found in the tropics, are fixed at 82 to 85 F. and 81 to 83 per cent relative humidity. The machines under test are operated continuously for four-hour periods on several successive days. Various types of machines were tested and it was found that the maximum loss of radiation output, in any machine, when all parts of the machine were *clean and free of dust*, was 5 per cent. On the other hand, if dust was allowed to accumulate on the parts of the machine the loss of radiation output arose, in some cases, to 15 per cent.

The conclusions drawn from this experimental work are that a well-designed and well-built roentgen-ray machine, when kept clean and free of dust, will operate satisfactorily, with only a negligible loss of radiation output when operated in an atmosphere with a relative humidity as high as 90 per cent. Navy specifications limit the allowable loss to 5 per cent.

Test work in connection with insulating materials for roentgen-ray use will be undertaken when time and facilities permit.

#### EXAMINATION OF NEW TRADE PRODUCTS

The depot's laboratories are frequently called on to examine and report on the suitability of new trade products for use by the medical department of the navy, and this work often requires the devising of new methods for conducting such examinations.

At Edgewood Arsenal, Md., the center of the chemical warfare activities of the army, the medical department of the navy has, since 1922, maintained a naval medical officer as its representative in the Medical Research Division, whose function has been to carry on anti-gas and medical research having particular application to the navy.

Commander E. W. Brown, Medical Corps, United States Navy, is the representative of the medical department at present detailed to this important duty. Commander Brown, in addition to being a doctor of medicine, holds the degree of doctor of philosophy in chemistry, and is, therefore, well qualified to conduct research along medicochemical lines.

Among the projects which have been undertaken, and in most cases carried to a successful conclusion, by the navy's medical representatives at Edgewood, may be mentioned: (1) the treatment of phosphorus burns; (2) the effects of burned smokeless powder; (3) a comparison of the methods of treating carbon monoxide poisoning, and (4) the toxicity and inflammability of refrigerants.

1. Phosphorus burns occur in certain industrial plants and may be expected in warfare, both on sea and land. Some method of treatment which can be applied rapidly and under almost any condition was sought for. As a result of investigation, it was found that a solution of copper sulphate, in the strength of from 3 per cent to 5 per cent, would combine with the phosphorus, forming an impervious red coat of copper phosphide. This coating arrested tissue destruction by the phosphorus and allowed undestroyed particles of the metal to be removed by forceps.

2. Following the turret accidents on the U. S. S. *Trenton* and the U. S. S. *Mississippi* several years ago, in which large quantities of smokeless powder were burned, there was found evidence that some of the casualties were due to the inhalation of toxic gases. Experiments were undertaken to determine the gases developed by powder fires in semiclosed, but relatively

large, compartments, and the effects of the flames and gases on animal subjects. It was found that a maximum temperature of 750 C. was obtained, with maximum concentrations of 37 per cent of carbon monoxide and 15 per cent of nitrous gases. Dangerous concentrations persisted for thirty minutes in the absence of artificial ventilation. Exposed animals developed either carbon monoxide poisoning, lung edema from nitrous gases, or a combination of both. Men removed from such an atmosphere should first be treated for carbon monoxide

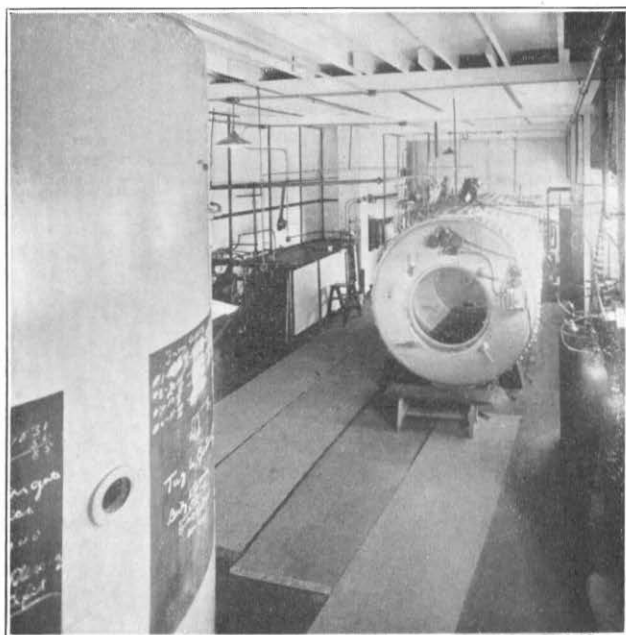


Fig. 2.—Compression chambers, Navy Yard, Washington, D. C.

poisoning and then carefully watched for the possible development of lung edema. Recommendations for a sprinkling system and more efficient ventilation in turrets were submitted.

3. Dogs were the subject of these experiments. After exposure to carbon monoxide, they were treated, and the rate of fall in the percentage saturation of the blood with the gas was followed. It was found that treatment with oxygen alone produced a fall almost as rapid as did treatment with oxygen plus 5 per cent of  $\text{CO}_2$ . The employment of ordinary air plus 5 per cent of  $\text{CO}_2$  was found to be inferior to either method of treatment, but is of value when oxygen cannot be obtained.

Tests have been carried on to determine the skin absorption of certain gases. Of these, nothing will be said other than that carbon monoxide does not appear to be absorbed by the skin, even when present in very high concentration.

4. This subject was investigated because of the need for a safe refrigerant for use in the small refrigerating units in submarines. It was ascertained that isobutane answered the requirements.

Dr. Brown is also engaged in other researches bearing on both the army and navy, but, as these are more or less confidential in nature, they will not be discussed.

Before going to Edgewood Arsenal for duty, Dr. Brown was at the Philadelphia Navy Yard, where he conducted a thorough and painstaking study of eighty-three cases of lead poisoning which occurred among oxyacetylene welders employed in cutting up old battleships. It was determined that the poisoning was induced by the inhalation of lead volatilized in fumes arising from the burning of paint adherent to scrap metal. Preventive measures were adopted as a result of this study.

Commander Duncan C. Walton, of the medical corps of the navy, is at present at the University of Wisconsin, where, under the supervision of Professor Loevenhart, he is carrying on experiments to determine the best method of protection against lachrymatory gases.

Not all of the personnel of the navy spends its time and lives its life in ships that sail the seas. Much time is spent by some in submarines beneath the surface of the sea; others fly to high altitudes in airplanes; while still others are subjected at frequent intervals to the hazards of diving. All of these activities present medical problems which must be solved in order that they may be conducted with a reasonable degree of safety, and much of the navy's research is concerned with them.

We are fortunate in having in the medical service of the navy not only the officers of the regular navy, but men distinguished in their profession in civil life, who, through their desire to increase the efficiency of their government, and with great generosity, give freely of their time and talents to aid us in our problems. No one of these men has been of greater value to us than Dr. Eugene F. DuBois, associate professor of medicine at the Cornell University Medical College and medical director of the Russell Sage Institute of Pathology. Dr. DuBois is a captain in the medical corps, United States Naval Reserve, and has recently completed a tour of active duty at the Bureau of Medicine and Surgery. It is not too much to say that his services have been invaluable.

#### SUBMARINE VENTILATION PROBLEMS

A submarine running submerged or at rest beneath the surface of the sea cannot, of course, take advantage of natural



ventilation. Therefore, an accumulation of  $\text{CO}_2$  occurs and, if the submergence be unduly prolonged, this may assume dangerous proportions. Captain DuBois has worked out a table which shows at a glance the percentage of  $\text{CO}_2$  which may be expected to accumulate in varying lengths of time under varying conditions. From this it can be told when it is necessary to use soda lime to absorb the  $\text{CO}_2$  and to keep it from reaching proportions in which it would be noxious, even if not deadly. It is also possible from DuBois' tables to foretell with a considerable degree of accuracy the length of time that survivors might live in a submarine after an accident. These tables have proved of great value to the navy and are used in all submarine operations.

During Captain DuBois' recent tour of duty in Washington, he made an airplane flight to an altitude of 23,200 feet in order to determine the effects of oxygen want and the efficacy of the Prouty type of oxygen apparatus in overcoming them.

Constant study is being made of means to increase the habitability of submarines by the Planning Division of the Bureau of Medicine and Surgery, and in the January, 1928, number of the *United States Naval Medical Bulletin*, Capt. Dudley N. Carpenter, Medical Corps, United States Navy, until recently head of the Planning Division, published a paper on this subject which brought together all the latest information and in which he made several useful recommendations.

#### DEEP DIVING EXPERIMENTS

Deep diving presents opportunities for research of a most important kind, and the navy is taking full advantage of them. At the Washington Navy Yard an experimental tank has been installed and it is here that naval medical officers are cooperating with other officers of the navy in an effort to discover safe means of rapid decompression and efficient methods for the prevention and treatment of "bends." Figure 2 shows the compression chambers used in diving experiments. At the left is a tank filled with water with windows through which the condition of the divers in the experimental tank can be observed. Any desired pressure can be produced. The long boiler-like tank is the decompression chamber where the divers are placed after being under pressure. Study of the effects of the substitution of certain inert gases, particularly helium, mixed with oxygen, for air, in the supply to divers who must operate at great depths and for long periods of time, is being made and gives promise of furnishing useful information. Already decompression tables which give far more satisfactory results than those formerly used have been devised and are being used.

#### RESEARCH IN AVIATION MEDICINE

Aviation medicine is another fertile field for research, and one that is being studied closely. In aviation medicine, the

navy has followed closely the methods of the army, but recently we have departed from these somewhat in the conduct of our school for flight surgeons. The school work is divided into three periods, the first of which is given to instruction in the basic medical sciences, an expert knowledge of which is essential to an understanding of the problems which will arise. In the second period, the school becomes a seminar; while the third period is devoted to training in flying and ground-school work and in a study of prospective aviators, through close and intimate contact with them.

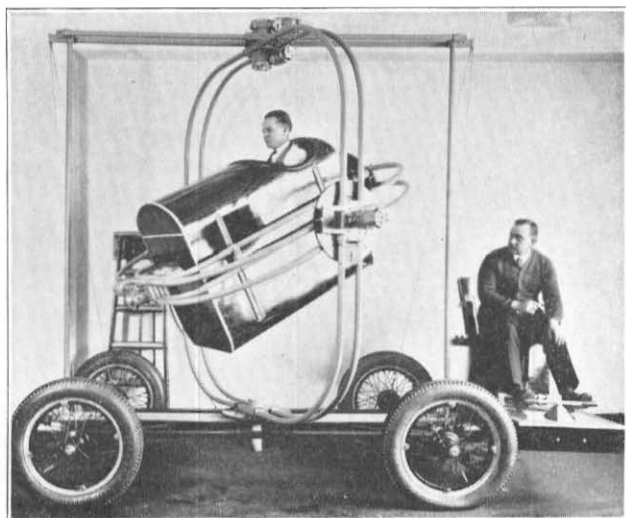


Fig. 3.—Ruggles Orientator.

Research work in aviation medicine has for its objects: (1) ways to determine the qualifications of applicants for aviation training, and (2) the hygiene of aviation. Why do certain qualities render candidates unfit for training, or make of them potential crashes? For example, what part is played by hyperphoria? What is the permissible degree of hyperphoria? Why do older pilots develop an excessive degree of exophoria? Are ocular calisthenics of any value in overcoming these defects? A careful statistical study, based on the records of several hundred persons, is now being made.

Study of coordination and the reaction time of aviators is of tremendous importance. What is the best method of determining them? The British rely on the Reid control indicator, an apparatus designed to measure and record the time required to perceive a given signal and perform the proper action. It

consists of a stationary fuselage equipped with control stick and rudder bar which are electrically connected with rows of colored lights on the dashboard. The lights flash in consonance with rudder and stick movements similar to those made in flying a plane. The instructor switches on the lights, which give the signal to the student. A time recording pen traces on a chronograph the time and steadiness of single and combined movements performed by the student. By comparing these tracings with established curves, the British classify the promising and doubtful candidates before actual flight training begins.

Our navy is conducting experiments with the Ruggles orientator (fig. 3), which is, essentially, the cockpit of an airplane suspended in three concentric rings. It is operated by motors controlled by the stick and rudder in the cockpit as well as by the stick and rudder in the hands of an instructor on the ground. The orientator may be put through any evolution that can be performed by a plane except going in a straight line forward or up and down. A graph attachment is being developed for the orientator (fig. 4), which will measure and record the reaction time of the candidate in any position, as well as record the movements of the stick and rudder. The orientator has an advantage over the Reid control indicator in that the candidate can be placed in various positions with reference to his environment.

It is expected that an analysis of a large number of examinations made with the orientator will show a correlation between flying ability and reaction time, or between flying ability and a curve of improvability of a definite contour. The graph attachment does away with the variable introduced by the personal makeup of the examiner.

Recently there has been developed by Lieutenant Commander Poppen, instructor in aviation medicine at the Naval Medical School, a very ingenious apparatus designed to set before the candidate two tasks; one visual, the other auditory. The visual task is on the pursuitmeter principle; the auditory task is automatically introduced. The apparatus is self-contained and operated, and the results of the test are mechanically measured. This apparatus is still in the stage of experimentation, but much is expected from it.

The rebreather is a very important piece of apparatus used in the examination of aviators. Combined with it, as used in making the test, are cumbersome and expensive pieces of psychological apparatus. Lieutenant Commander Armstrong of the medical corps has succeeded in modifying these so that their cost is now moderate and their size such that they may easily be transported in a box of suitcase size.

It has been found that the sound perception of the ear becomes dulled as flight time increases. At the Naval Research Laboratory tests are being conducted to determine the intensity of radio signal which will have the least fatiguing effect in

radio helmets. The operators are tested with the audiometer after flights of varying lengths.

Changes in blood pressure brought about by conditions of stress, produced in the orientator, the Bárány chair, and in airplanes during flight, are being studied by means of the self-recording sphygmomanometer.

As has been already suggested, experiments are being carried on in connection with certain respiratory problems which arise in flying at high altitudes. Subjection to low pressures in low pressure chambers to determine the maximum ceiling at which aviators may hope to fly when equipped with oxygen

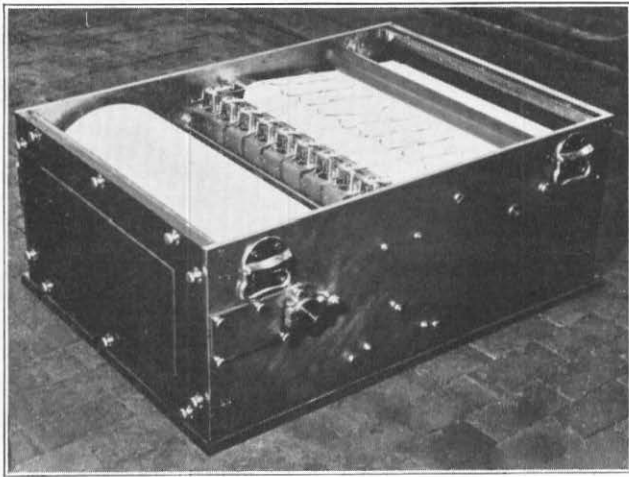


Fig. 4.—Chronograph attachment for recording reactions in Ruggles Orientator.

apparatus, are contemplated. The concentration of oxygen in the alveolar air under various systems of supply will also be studied.

A comparison of the Schneider index and the Turner index has recently been made in a small series of cases. Both of these are indexes of circulatory efficiency, and the Schneider index has long been used in connection with the examination of aviators. The study made has convinced us that the Schneider index is superior to the Turner index for this purpose.

There is a class of diseases, or of abnormal conditions, which have a peculiar bearing on aviation. In themselves they do not disqualify for the pursuit of most occupations, but they do disqualify for aviation. Conspicuous among these conditions is "staleness," while various phobias, compulsions and

anxieties are predicated entirely on the vicissitudes of aviation. These are being studied in order that their real causes may be determined and methods of prevention devised.

#### MEDICAL PROBLEMS OF THE TROPICS

When the United States became a world power and acquired interests and possessions in the tropics, medical problems new to most of us were introduced, and research on these problems has been conducted, in large part, by medical officers of the navy.

Although Haiti is in no sense a possession of the United States, it has been the privilege, since 1915, of naval medical officers to assist this one of our neighboring republics in establishing an efficient health service and in developing an efficient system of sanitation.

At the time the Americans entered Haiti, all matters relative to the medical profession were in a chaotic state. Treaty regulations then placed all public health and hospital services in the hands of American naval medical officers. About two years ago, the president of Haiti transferred the medical school at Port au Prince to the care of the Director General of the Public Health Service, a naval medical officer. Thus, Haiti was placed in the unique position of having all its medical activities controlled by one man. The opportunity thus given to the navy is a great one and the responsibility entailed is tremendous. A great research problem was created, and great things have been accomplished in its solution.

Modern sanitation has been introduced throughout the island; drainage projects of great magnitude have been undertaken and completed; native clinics have been established in the outlying districts; ten hospitals have been constructed or taken over and modernized; a training school for native nurses has been successfully operated in connection with the splendid 500-bed hospital established at Port au Prince; much progress has been made in the eradication of malaria, filariasis, yaws and other tropical diseases; the economic condition of the natives has been improved; and last but not least, a modern medical school where native Haitians receive instruction which will enable them to take up and carry on the good work which has been started by naval medical officers, is now in operation. Of this school more must be said.

As soon as the transfer of the school to the Public Health Service was assured, and funds were allotted for the construction of a new building, the aid of the Rockefeller Foundation was sought and granted. Under its auspices, eight young Haitian physicians are now doing graduate work in the United States and in France in such subjects as anatomy, physiology, bacteriology, pathology, medicine, surgery, obstetrics and public health work. When they have completed their graduate work, these men will return to Haiti and form the nucleus of the new teaching staff in the recently completed

medical school. Through the courtesy of the Rockefeller Foundation, the school has been equipped with laboratory apparatus and material sufficient to enable it properly to perform its function as a training school for Haitian physicians. The traveling country clinics care for from 35,000 to 45,000 persons monthly. More than 100 places are visited from two to four times every month. This work is gradually being turned over to native physicians by the naval medical officers who have been doing it since 1915. The trend in Haiti today is towards state medicine and, under the economic conditions which exist, this will be a necessity for years to come.

The Virgin Islands of the United States were purchased from Denmark in 1917. Since that time all of their medical problems have been handled by naval medical officers. These have involved much research. The Virgin Islands, so far as is known, are the only place in the world where a health record of every inhabitant is kept. A record is opened at birth and is continued throughout the life of the individual. It is easy to see what a valuable source of information these will form in years to come.

Typhoid fever was rife in the Virgin Islands at the time of their transfer to the United States. In August, 1918, all members of the population between the ages of 5 and 45 years were vaccinated against this disease. Since then, no cases of typhoid have been reported in the islands.

Pellagra, another scourge of the Virgin Islands, has been practically eradicated by the simple method of teaching the people to eat a proper diet and by improving their economic condition so that they have been able to get away from their former customary diet of corn meal and molasses.

In Guam, another of our distant island possessions, naval medical officers, through research and the application of the results of research, have been able to convert what was formerly a hotbed of disease into a comparatively healthful community. Gangosa presented the greatest problem in Guam. The island was full of it and it was frightful in its effects. Until 1904, it was thought that this was a manifestation of syphilis. After this it came to be considered either a sequel of yaws or an independent disease, and now, because of the work done by Captain Butler of the medical corps in Haiti, many are once again of the opinion that yaws, gangosa and syphilis are manifestations of infection with the same treponema and are identical.

If one will read the description of syphilis as presented in Sydenham's "History and Treatment of the Venereal Disease" it will be noted that the clinical manifestations are rather those of yaws, as observed in the rural districts of Haiti, than the picture of syphilis noted in temperate climate clinics. As regards the American origin of syphilis, Sydenham states, "It seems probable, therefore, to me, that the Spaniards, who first brought this disease into Europe, were infected with it

by a contagion communicated from the Negroes which they purchased in Africa." Slaves from Africa were brought into the islands of the new world as early as 1512 and with them, undoubtedly, came yaws. It is impossible to differentiate the tertiary lesions of yaws from those of syphilis. When you consider that in one year our medical officers in Haiti treated 167,267 cases of yaws or syphilis, the wealth of their experience will be understood. A disputed point has been the question of involvement of the central nervous system in yaws, and research work is now going on in our clinics, in the rural districts of Haiti, to clear up this point.

Because of the severity of the reactions which so frequently followed inoculation with triple typhoid vaccine—that is, vaccine containing typhoid, paratyphoid A, and paratyphoid B bacilli—the navy in November, 1924, returned to the use of the straight typhoid vaccine. From Jan. 1, 1925, to July 1, 1927, 254,413 separate inoculations were given and the severe reactions were very few. Other reasons for changing from the triple vaccine were the multiplicity of strains of paratyphoid B and the large number of strains of paratyphoid A, and the fact that few cases of paratyphoid fever were to be expected in the navy. Furthermore, it seems not improbable that inoculation with the typhoid bacillus protects against infection with paratyphoid bacilli, as a result of group agglutination. An epidemic of typhoid and paratyphoid fevers which occurred in Guam was terminated by inoculations with straight typhoid vaccine. It was also noted that the incidence of other types of enteritis was reduced following these inoculations.

For the past four years the Preventive Medicine Section of the Bureau of Medicine and Surgery has been making an intensive epidemiological study of all outbreaks of food poisoning in the navy. During this period there were twenty outbreaks, the number of cases of poisoning involved being 2,096. Practically every one of these outbreaks was traced to a different food, but the causative agent in twelve, where bacteriologic determination was made, incriminated the Gaertner bacillus group. An outbreak of practical interest was a serious one involving 265 men, on the U. S. S. *Maryland*, due to corn beef hash which had been contaminated with *B. pestis caviae*, an organism used in one of the rat virus exterminators.

From what has been said it will be seen that the navy has many medical research problems peculiarly its own and that it also has to meet many of the same problems that confront the research worker in civil life. The navy is a great organization of scientists, industrial workers, pioneers in many phases of its activity, and its progress is continuous. With every step forward, new medical problems arise, so it need not be feared that the field of medical research in the navy will ever be an unfruitful one.









